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Land-use change impacts on thermal properties of typical chernozems

Mariia Velichenko and Tatiana Arkhangelskaya
Soil Science Faculty, Moscow State University, Moscow, Russian Federation (m.velichenko@gmail.com)

Changes in land use affect soil organic carbon, bulk density and hence soil thermal properties. Generally soil thermal diffusivity, thermal conductivity and volumetric heat capacity grow with bulk density and decrease when organic carbon is increased. But the quantitative expression of these effects may vary in different soils.

Typical chernozems were studied in Kursk region (51˚08’49"N, 36˚25’48"E and 51˚36’13"N, 36˚15’14"E). The research objects were virgin soil, arable soil, 4-year fallow and 15-year fallow. Thermal diffusivity was studied using the unsteady-state method. Heat capacity was measured using the differential scanning calorimetry, and thermal conductivity was calculated from data on thermal diffusivity and heat capacity.

Thermal diffusivity of virgin chernozem was the lowest in the upper part of A1 horizon with bulk density 0.89 g cm^{-1} and organic carbon 4.5 %: it varied from $1.16\times10^{-7}m^2s^{-1}$ for air-dry samples to $2.48\times10^{-7}m^2s^{-1}$ for capillary-moistened ones. When moving from 10–17 cm layer to 50–57 cm layer within the A1 horizon and from A1 to AB horizon thermal diffusivity grew by about 10 %. In the lower parts of soil profile thermal diffusivity was almost similar for all studied depths, varying with moisture from 1.56 to $3.20\times10^{-7}m^2s^{-1}$. Volumetric heat capacity also grew with depth (from 0.84 to 1.15 $kJcm^{-3}K^{-1}$ for air-dry samples), and calculated thermal conductivity had similar trend. Soil profile was texturally homogeneous; so we explain the observed differences in thermal properties by low bulk density of A1 and AB horizons and by high organic carbon in the upper part of the profile.

The upper layers of arable soil were compacted and contained less carbon compared to the same depths in A1 horizon of virgin soil. The bulk density of the 0–7 cm layer was 1.19 g cm^{-1} and organic carbon was 3.1 %. As a result, thermal diffusivity grew up to $1.30\times10^{-7}m^2s^{-1}$ for air-dry samples and $3.15\times10^{-7}m^2s^{-1}$ for capillary-moistened ones. The lowest in the profile now was the thermal diffusivity of the lower part of the Ap horizon.

After 15 years under fallow thermal diffusivity of the upper layer decreased to $1.21\times10^{-7}m^2s^{-1}$ for air-dry samples and to $3.10\times10^{-7}m^2s^{-1}$ for the capillary-moistened ones. So it was still greater than that of the virgin soil, and it means that 15 years under fallow were not enough to restore the initial values of soil thermal properties.